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The measurement of dielectric properties at varying temperatures

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The use of dielectric heating for different purposes has caused an increased interest in the measurement of the dielectric properties of the materials at varying temperatures. Generally, resonance methods are used (1), and different dielectric cells have been constructed for this purpose (2).

The resonance method is not convenient when the material changes during the heating. This happens with moist wood, and is of practical importance in connection with R.F. drying and gluing of wood. A possible method is then to measure the power dissipated in the specimen directly with a radio-frequency wattmeter (3). But as the wattmeter used in this method depends on a resonance condition there seems to be difficulties when the dielectric constant changes during the heating.

Another method is to make a calorimetric measurement of the power loss (4). The temperature change of the specimen is observed and thereafter a similar specimen with built-in heaters is heated by D.C. for calibration. — When trying to determine the dielectric properties of moist wood by this method it appeared to be impossible to get an even heating without too great a loss of heat through the conductors for the heating current. Further, the method could not be used above 100° C, because the temperature changed only slowly when the moisture boiled away. For this reason a modified calorimetric method has been worked out, that has given good results even for wood.

The apparatus consists of a commercial generator for dielectric heating (Redifon R.H. 7, 2 kW). The anode current is measured with a separate D.C. ammeter and the R.F. high-voltage is measured by a capacity potential-divider and a vacuum tube voltmeter. The specimen consists of two slabs of wood ($10 \times 12 \times 3$ cm) with a thin earth-connected copper foil between them and with the high-voltage electrodes on each side. The thermocouple that measures the temperature of the specimen lies along the copper foil. Owing to this arrangement the thermocouple has no influence on the field distribution. A variable air condenser of 50 pF is connected in parallel with the specimen.

During the first part of the experiment the specimen is heated with R.F., and the anode current, the R.F. high-voltage and the temperature are observed during the heating. In the second part of the experiment the specimen and the copper foil are removed. This diminishes the capacitance and the resistance of the load and must be compensated by increasing the air condenser and by connecting a separate resistor in parallel with the condenser. By adjusting the air condenser and the resistor the anode current and the R.F. high-voltage can be brought to the same values as during the first part of the experiment. The dielectric properties of the specimen can be computed from the capacitance of the air condenser, the R.F. high-voltage and the power in the resistor (5).

The resistor consists of a vertical tube of pyrex with diameter 17 mm and length 200 mm. A slow stream of water passes along the tube, and the heating of the water gives directly the power dissipated in the specimen. In the lowest point of the pyrex tube there is a small quantity of mercury in contact with a sealed-in tungsten wire connected to the high-voltage. At the top the pyrex tube is sealed with picein into a grounded metal lid, through which a metal rod can be screwed into the pyrex tube. The cold water is supplied through a long and narrow tube to the lowest point of the pyrex tube, is heated between the mercury and the metal rod and leaves the pyrex tube at the top. This arrangement prevents difficulties due to the formation of air bubbles. The temperature is measured with two mercury thermometers.

The accuracy of the determination of the dielectric constant and the loss factor has amounted to about five percents in our preliminary experiments, but it may be improved by stabilization of the line voltage and better control of the temperature of the cold water. With this apparatus it will be possible to measure the power dissipated in a glue line when cured by dielectric heating.

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